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MPES NEGATIVE G RESTRAINT STRAP DESIGN OPTIONS

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This report documents the design options which the Navy will investigate for incorporating negative G restraint onto the Navy Maximum Performance Ejection System (MPES) seat structure. Restraint configuration and seat/man separation during ejection are addressed.

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BACKGROUND

The Navy Maximum Performance Ejection System (MPES) program is furthering the advancement and state-of-the-art of various ejection system technologies. The program's technologies are not only geared to the performance of components and systems during an ejection scenario but also to in-flight performance. It is important not to lose sight of the fact that the ejection seat system is also part of the cockpit crew station and every effort should be made to enable the crewman to perform his duties comfortably and without undue strain.

INTRODUCTION

A problem which has been frequently encountered in fighter aircraft during adverse aircraft maneuvers (performed voluntarily or otherwise) is the problem of negative G or the crewman being forced away from the seat lid due to upward (toe-to-head) acceleration during high performance aircraft maneuvers. When such a condition occurs while the crewman is not properly restrained, he is forced away from the seat; he may then have a problem reaching aircraft controls or seeing his instruments or displays. Most ejection seat restraint systems do not offer optimum negative G restraint. The standard Navy restraint incorporates an MA-2 torso harness which is a combination torso restraint and parachute harness; it is donned by the crewman before he enters the cockpit and is taken off after he leaves the cockpit. Restraint is provided by a lap belt and two shoulder straps. It is of utmost importance that the crewman adjust his lap belt to a tight fit if he is to be restrained properly while undergoing a negative G maneuver. To be effective the lap belt must pull down on the crewman's upper things in order to restrain him to the seat lid. If the lap belt "rides up" above the crewman's hips then he will be forced off the seat lid by the negative G forces until his torso slides through the lap belt to the point where his thighs are forced into the lap belt. However, by this time he may be too far off his seat and experiencing difficulty in maintaining control of his own movement as well as maintaining control of the aircraft.

The importance of keeping a tight fit of the lap belt over the upper thighs results in a fairly effective yet simple solution which requires a connecting strap between the lap belt and the seat lid. Some aircraft seats have begun to utilize such a strap which is located between the crewman's thighs. This strap is essentially a "tie down" strap since it keeps the lap belt from "riding up" on the crewman's waist. Once again, this tie down strap or negative G strap must be tightly adjusted if it is to be effective.

Negative G Restraint Requirements

For MPES, the design and development effort intends to satisfy the following requirements pertaining to the negative G restraint:

- Firm restraint (zero clearance) of the crewman's buttocks to the seat lid for negative G accelerations up to -3G.

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- Negative G strap tensile strength of 1500 pounds.
- Negative G strap release for man/seat separation during ejection.
- No maintenance.

MPES Design Options

The MPES can easily accommodate the standard MA-2 torso harness modified with a tie down strap. However, an effort is being conducted to implement a seat-mounted torso restraint/parachute harness. This harness will have a single point release fitting. Currently, two negative G restraint approaches are being considered for this restraint system. Figure 1 shows a general layout of the MPES torso restraint with a standard tie down strap which is fastened between the seat lid and the torso restraint single point release mechanism. The second approach involves fastening the lower posterior torso straps (or buttock straps) of the harness firmly to the seat lid as shown in figure 2.

These straps are located under the crewman's buttocks and are connected to the lap belt straps as shown in figure 2. By tightening the lap belt straps, the crewman is also tightening the buttock straps. Essentially, the restraint straps are being tightened around his thighs, and with the buttock strap fastened tightly to the seat lid, the crewman becomes restrained tightly to the seat lid.

For the first tie-down strap approach, the strap will be permanently fastened to the single point release fitting. The strap will be anchored to the seat lid at a point between the crewman's thighs. This anchor point will be on the seat lid approximately 12 inches forward of the crewman back tangent plane. It is critical that the length of the tie down strap not be too long to allow the lap belt to ride up on the crewman's torso. A decision will have to be made as to whether or not a fixed length of strap will be used or an adjustable strap will be used. For man/seat separation during ejection the tie-down strap must release from the seat lid.

For the second design configuration, the harness single-point release fitting will have to be permanently fastened to a shoulder strap or lap belt. In this configuration, it is critical for the crewman to keep his lap belt properly tightened to prevent it from riding up on his torso or else he negates the function of the posterior lower torso strap (buttock strap) attachment to the seat lid. This design, however, should still be an improvement over current seat restraints since the attachment of the buttock straps to the seat lid should provide added restraint against negative G.

Seat/Man Separation

For both negative G restraint designs, it is necessary to provide a release mechanism for the seat/man separation during ejection. Two modes - mechanical and ballistic - are being considered for release of the negative G restraint. A ballistic actuated release mechanism can be easily utilized

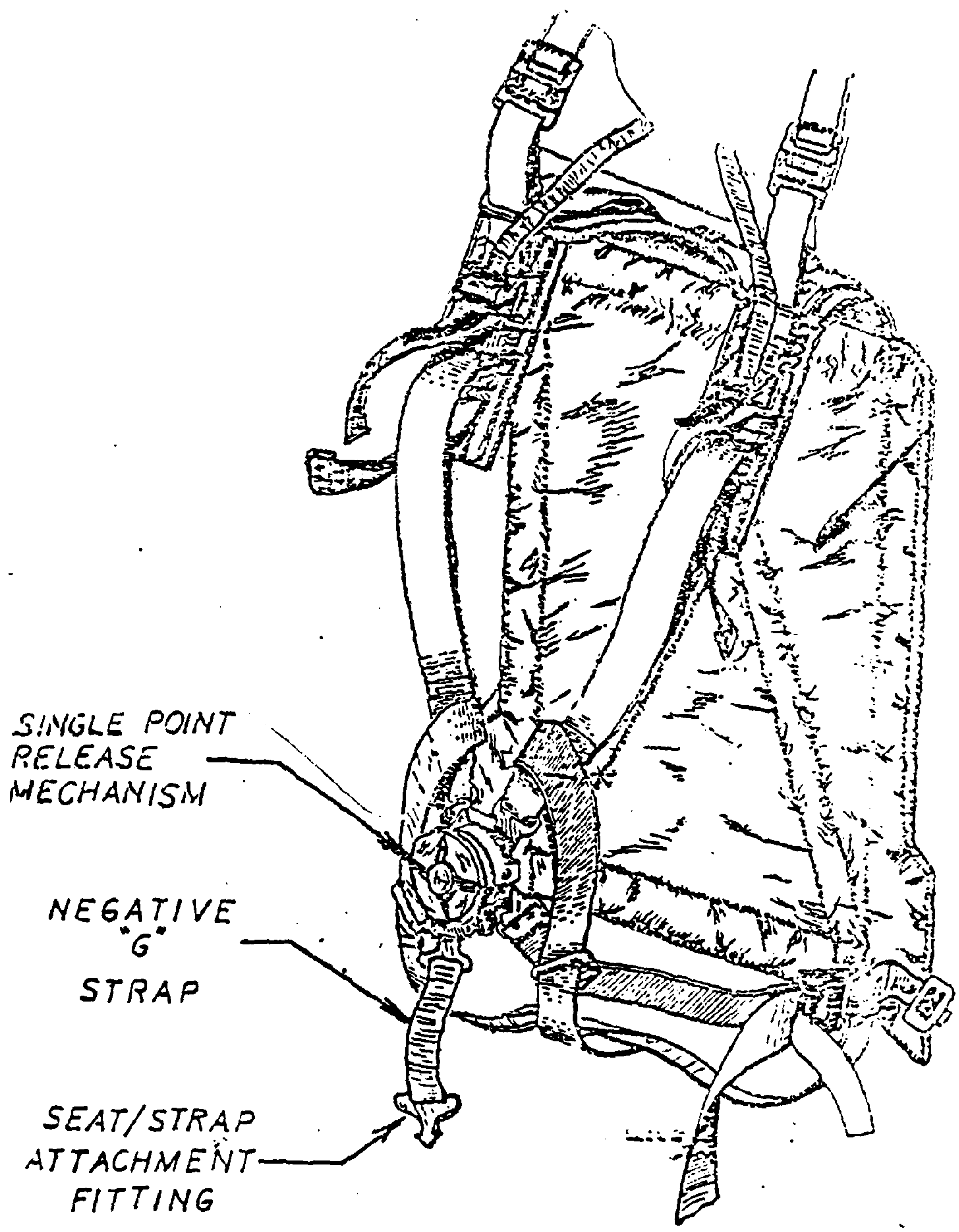

Figure 1 - MPES Seat Mounted Restraint With
Negative G Tie Down Strap

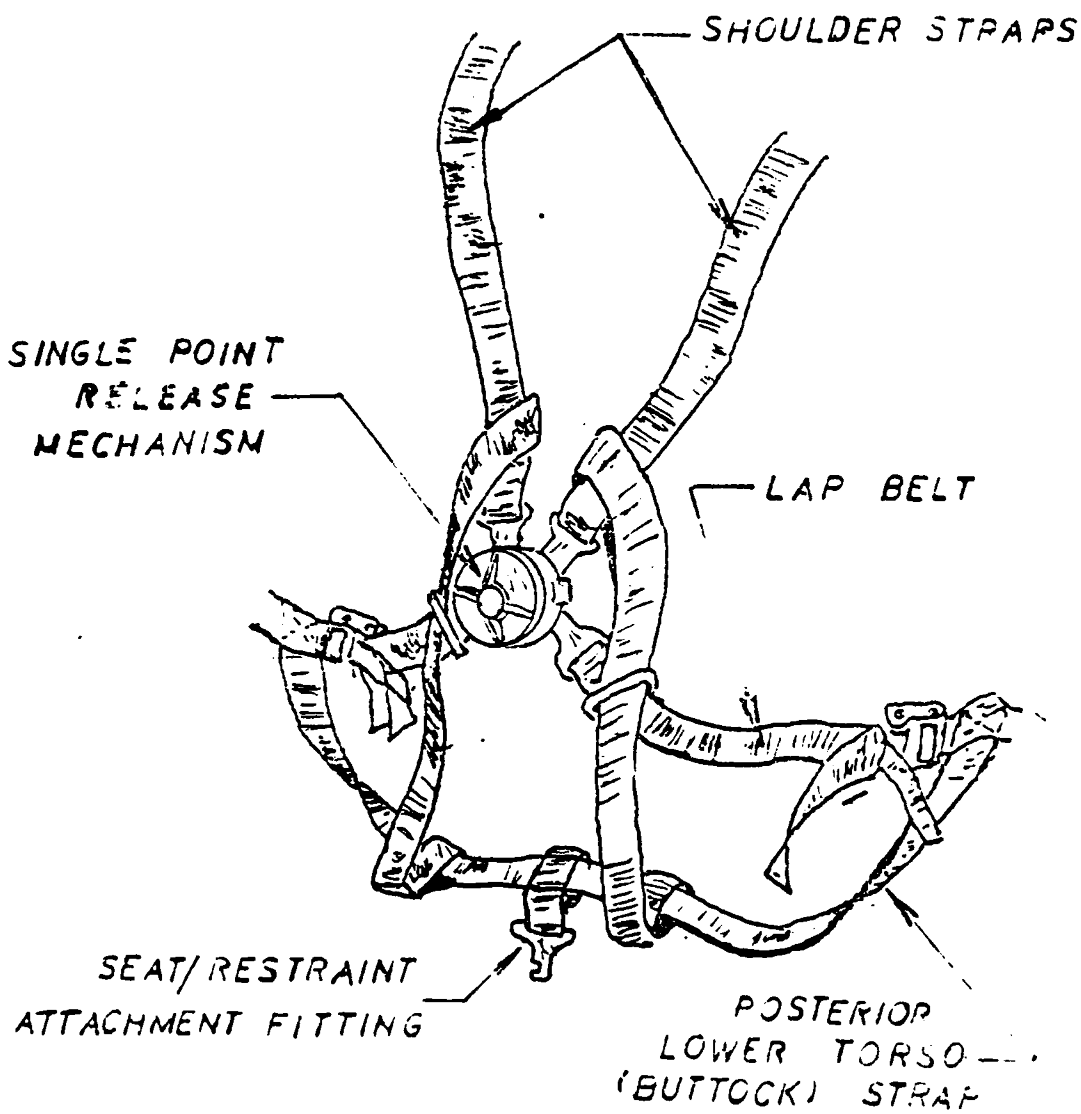

Figure 2 - MPES Seat Mounted Restraint With Seat/Buttock Strap Attachment

since such mechanisms are state-of-the-art and are commonly used on ejection systems. For this type of operation, gas pressure or electric current would have to be channeled to the release mechanism initiator. However, to simplify the release, a mechanical actuation method is being investigated. This function will occur when the crewman pulls the ejection initiation handle. A cable or linkage from the ejection initiation handle to the negative G restraint release mechanism is required for actuating the release mechanism.

Comments

As with most restraint systems, it is important to provide comfort for the crewman. If restraint straps are bothersome to the crewman, he may adjust straps loosely and render the restraint ineffective during the inflight situation for which the restraint is intended to function. With the tie-down strap, there is some question as to whether or not this strap should be an adjustable strap. The argument against the adjustable strap is that the crewman will over-loosen it. If the strap is kept at a fixed length such that it always keeps the tie-down strap/lap-belt connection low enough to allow the lap belts to remain snug on the crewman's upper thigh, then there may be a discomfort problem for larger crewmen.

The mechanical release of the negative G restraint occurs when the ejection handle is initiated. Simultaneously the crewman is being positioned by his inertia reel and lap belt retraction mechanism (unique to MPES). The question to be answered is what effect release of the negative G strap has on pre-ejection positioning of the crewman, primarily pertaining to lap belt restraint. Again, it appears it is left to the crewman to fly with a snug lap belt.

Lastly, the matter of maintenance must be considered in the design of the MPES negative G restraint. Since there will be hardware attached to the seat lid, it is important to consider the implications of maintaining any ejection seat components where the maintenance task may require seat lid removal.

CONCLUSION

Preliminary investigation shows that the forementioned negative G restraint configurations are viable design approaches. The restraint systems will be fabricated and incorporated into MPES. Human subjects will be used for evaluation of the negative G restraint. Areas of concern which will be studied are

- Crewman comfort
- Ease of donning/adjusting the restraint.
- Restraint release for man/seat separation.

For measuring effectiveness of the restraint under the negative G environment, the seat/man configuration will be suspended upside-down (simulating a -1G environment) and measurements and observations will be noted.

The NADC centrifuge also looms as a possible test bed for testing the negative G restraint under a variety of negative G profiles.

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